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DEVELOPMENT OF INDICES OF YELLOW PERCH ABUNDANCE IN CASCADE RESERVOIR, IDAHO

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Abstract

Studies were conducted in 1986 and 1987 on Cascade Reservoir to determine: (1) when and where yellow perch *Perca flavescens* spawn, (2) techniques that could be used to obtain an index of perch abundance, (3) the age composition and growth rate of perch, and (4) to assess changes in species composition. Perch spawned throughout the main body of the reservoir in late April and early May in 1986. Few egg strands were found in the northern arms. Tow nets were effective for capturing subyearling perch (up to about 20 mm in length), with nighttime catches larger than those made in daylight. Seine hauls along the shoreline were effective for catching subyearling and yearling perch (253,300 in 1987), with the age composition apparently dependent on year-class strength. Yearling and older perch were caught by trawling a net with a 32 mm mesh cod end in late summer, and by overnight sets of experimental gill nets. In an abbreviated creel census, we found that catch rates in 1987 were similar to the higher rates observed in previous years. Growth rates of perch in the reservoir were relatively good, but variable, and may be affected by fluctuations in year-class strength (seine catch rates of subyearlings in 1987 were 130 times higher than in 1986).

Recommendations

1. Randomly select permanent beach seining locations and seine each site once per year between 15 August and 15 September. Enumerate perch and determine length frequency distribution of catch.

2. Collect data on ambient air temperature, mean daily reservoir elevation, mean daily water temperature at outflow, and measure wind velocity during spring spawning period.

3. Correlate mean catch of age 0 perch and meteorological data to determine factors that regulate yellow perch abundance in Cascade Reservoir. Factors include mean air and water temperature for 15 days after iceout, summer degree days (>14°), and mean wind velocity during spawning and early larval stage.

4. Collect creel census data on 1 weekend day per week from June through August of each year. Data would include number of anglers, hours fished, number and species of fish caught, scale samples from perch, and length frequency of perch in the catch. This data can be used to track the perch fishery and to determine whether beach seining data accurately reflects future fishing success.

Introduction

The primary goal of this project was to provide biologists with standardized sampling techniques to allow efficient monitoring of annual fluctuations in yellow perch *(Perca flavescens)* abundance in Cascade Reservoir. An index of abundance will provide a basis for the identification of: (1) factors which regulate yellow perch abundance, (2) optimum levels of yellow perch abundance, (3) species interactions, and (4) prediction of angler success. Techniques investigated for monitoring perch abundance included tow netting, beach seining, trawling, gill netting, and angler creel survey.

A second goal of the project was to see if growth rates of yellow perch are variable between years and related to abundance of a year-class of fish. Age information was used with data from the creel survey and from beach seine, trawl, and gill net catches, to determine year class abundance of yellow perch and relative contributions to the fishery of each age class.

Cascade Reservoir began filling in 1948 and reached full storage in 1957 (USGS 1984). During the first few years fishing was good for rainbow trout *(Oncorhynchus mykiss)* and kokanee salmon (0. *nerka),* but then northern squawfish *(Ptychocheilus oregonensis)* became a dominant species (Casey 1962). In 1958 chemical treatment of the major tributaries was initiated to reduce northern squawfish abundance. Rotenone drip stations were used until 1967 at major tributaries during spring. spawning migrations. Between 1968 and 1974 squawfish eradication efforts continued using squoxin. By 1974 northern squawfish abundance had been significantly reduced (Welsh 1975). Since 1974 naturally produced yellow perch and hatchery rainbow trout and coho salmon *(Oncorhynchus kisutch)* have made up most of the harvest (Welsh 1976; Reininger et al. 1982).

Cascade Reservoir supports one of the most popular fisheries in Idaho (Mallet 1980). Anglers fished more than 400,000 hours during an 11 month period in 1980-1981 and yellow perch made up over 70% of the harvest (Reininger et al. 1983). During the June 1986 to May 1987 period of the most recent creel survey, anglers fished 400,560 hours and caught 528,000 yellow perch (Anderson et al. 1987). Yellow perch made up 75 to 90% of the catch except during October, November, and April. Angler success has been variable on Cascade Reservoir, perhaps a result of large fluctuations in yellow perch year class strength.

Objectives

1. Determine the time, location and temperature, at which yellow perch spawning occurs.

2. Develop techniques for establishing an index of abundance of yellow perch.

3. Determine age composition and growth rates of yellow perch in Cascade Reservoir.

4. Identify changes in species composition within the reservoir.

Study Area

Cascade Reservoir, created by the construction of an earth-fill dam across the North Fork of the Payette River, is located near the town of Cascade in west-central Idaho (Figure 1). The Bureau of Reclamation used the reservoir to store water for irrigated lands in the Payette Division of the Boise Project and hydropower production at Cascade Dam and the Black Canyon Power Plant near Emmett, Idaho.

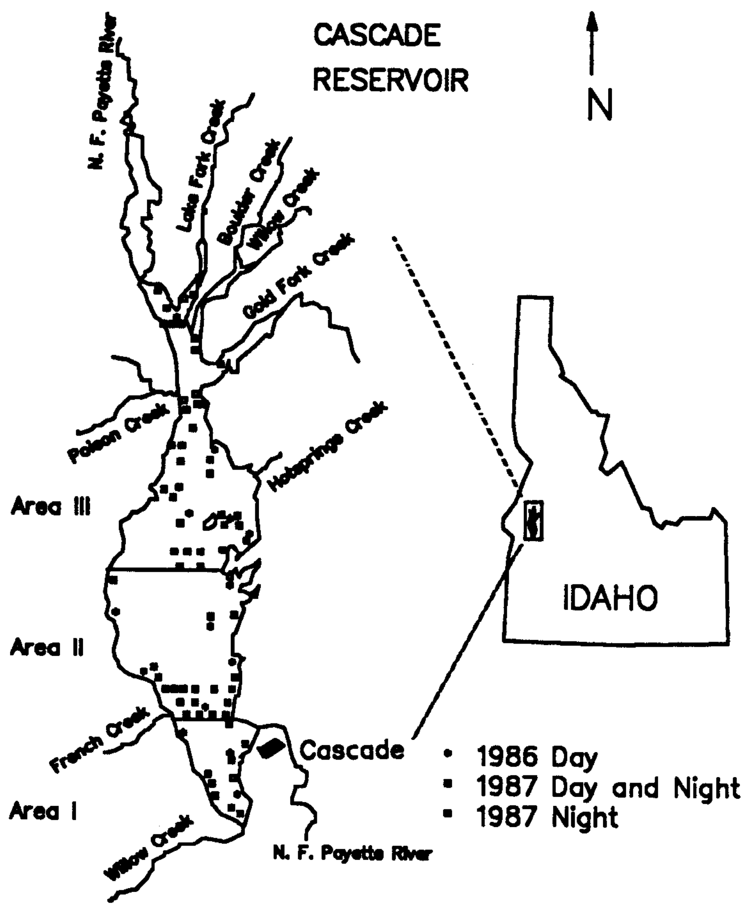

Figure 1. Map of Cascade Reservoir with 1986 day and 1987 day and night tow net sampling locations.

Cascade Reservoir had a surface area of 28,300 acres at full pool, a length of 27.4 km, a maximum width of 6.4 km, and a mean depth of 7.6 m. Four major tributaries, forming large embayments, entered the reservoir at the northern end. The embayments are relatively narrow with submerged tree stumps, steep sand beaches, and large mud flats. The west side of the reservoir had a mud and silt substrate and a shallow sloping shoreline. On the east side the shoreline was moderately sloping with a sand substrate.

The reservoir was considered mesotrophic by Klahr (1986). Clark and Wroten (1975) reported nutrient additions to the reservoir resulting from point and nonpoint sources. Point sources included effluent from the City of McCall sewage treatment plant and leaching from the McCall landfill. Nonpoint sources were believed to be the largest contributor of nutrients with livestock grazing, agriculture, and sivicultural practices being the primary sources (Zimmer 1983).

Eutrophication of the reservoir has resulted in summer algae blooms with diatoms (Cyanophyta) most abundant during May-July, and blue-green algae (Chrysophyta) dominant during August-November (Clark and Wroten 1975). Reininger et al. (1982) reported oxygen depletion in the hypolimnion. Low oxygen conditions occurred in the hypolimnion twice yearly during periods of stagnation (summer stratification and winter ice cover) when decomposition of organic matter used the available oxygen (Klahr 1986).

Methods

Spawning.

The time, location, and temperature at which yellow perch spawning occurred was assessed by walking the shoreline during April and May 1986. Randomly selected shoreline areas were sampled throughout the reservoir, and spawning locations were identified by the presence of egg strands washed up on the beach. Time of spawning was estimated by monitoring egg strands on a submerged conifer tree which the perch used as spawning substrate. The conifer, located near Sugerloaf Island, was monitored almost daily from mid-April to mid-May and egg strands enumerated and removed from the tree. Surface water temperatures were monitored.

Indices of abundance.

Techniques investigated to monitor annual fluctuations in abundance of yellow perch included: (1) collection of larval fish in plankton tow nets, (2) collection of age 0 and I fish during late summer with a beach seine, (3) collection of age I and older fish in an otter trawl, (4) collection of age I and older fish in experimental gill nets, and (5) collection of data for age II and older fish via a creel survey. In 1986, sampling was conducted during daylight, except for gill nets which were fished from dusk until dawn the following day. In 1987, tow netting and trawling were conducted during day and night, gill netting was discontinued, and a creel survey was conducted.

We sampled with tow nets, a beach seine, and a trawl in 1986 and determined sample sizes for 1987 from mean catches and coefficients of variation obtained in 1986. Minimum sample size was calculated to detect 50% differences between means with a 10% probability of a type II error. Neyman allocation based on size of each strata was used to determine sample sizes for individual strata.

Tow Nets.-Pelagic larval fish were sampled with paired conical plankton tow nets (0.5 m diameter, 2.0 m length, and 1.0 mm stretch mesh) from 28 May to 27 June 1986 and from 15 June to 3 July. 1987.

Tow nets were suspended from a 3.7 m crossbar, mounted midship, which positioned them in undisturbed water. A standardized haul consisted of towing the nets for 5 minutes at 1.28 m/s. During May 1986, the tows were oblique: 1 minute each at surface, one-meter, two-meter, and three-meter depths. All tows were made at the surface during June 1986 and in 1987. Velocity was measured with a handheld pitot tube. All sampling was conducted during daylight in 1986, and during day and night in 1987.

Sample locations were selected by stratified random design in 1986. The reservoir was stratified by area and depth. Fifteen permanent stations were selected, 3 in area I, and 6 in areas II and III (Figure 1). Stations were equally distributed between three depth strata; shallow (0-4.6 m), intermediate (4.5-9.1 m), and deep (>9.1 m) water. Three tows were conducted at each sampling location per sampling period. Sampling periods were 28 May-2 June (SP 1), 11-13 June (SP 2), and 24-27 June (SP 3).

In 1987, sampling locations were randomly selected from the same depth strata as in 1986, however, the reservoir was not stratified by area. Eighty-seven sampling sites were selected; 17 in shallow, 35 in intermediate, and 35 in deep water. We fished 26 sites during the day and night between 15-25 June 1987 to determine whether night sampling would be more effective than day sampling. Sites were fished both day and night within the same 24 hour period when possible. A total of 26 day and 66 night tows were made in 1987 (Figure 1).

Catches from the two nets were combined and fixed in 10%o formalin. After fixation, fish larvae were separated from plankton and preserved in 70% ethanol. In the laboratory, larvae in each sample were counted and a random sample of 30 selected from a grid marked tray for identification and length measurement to the nearest 0.5 mm, using a variable power dissecting scope.

Seining.-Yellow perch were sampled with a 2.4 m deep x 30.5 m long beach seine during September-October of 1986 and August-September of 1987. The seine was constructed with a 2.4 m x 2.4 m x 2.4 m bag and 6.35 mm knotless nylon mesh. A standard haul consisted of anchoring one end of the seine onshore and deploying the net in a semicircle using a small boat. The boat was beached and the seine pulled straight into the shoreline.

Thirteen randomly selected locations were seined in 1986 (Figure 2). Three hauls were made at each location in September and in October, when possible. Thirty-nine hauls were made in September and 36 in October: low water prevented sampling at 3 sites in October.

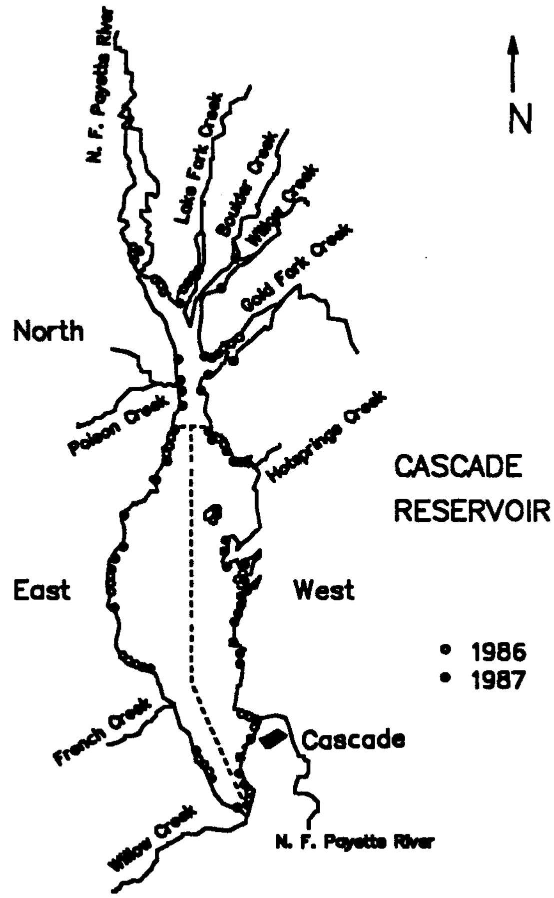

Figure 2. Beach seine sampling locations at Cascade Reservoir, 1986 and 1987.

In 1987, the reservoir was divided into three strata, (north, west, and east) to reduce sample variance and determine if any of the three were representative of the entire reservoir. Forty-nine locations were sampled in 1987; 17 in the north, 12 in the west, and 20 in the east (Figure 2).

All fish captured in the seine in 1986 were enumerated and measured for total lengths and a subsample of yellow perch was randomly selected for weights. In 1987, catches were large, so estimates of the number of young-of-the-year perch were made volumetrically. We placed the perch into a graduated bucket and measured the amount of water displaced. We made repeated counts of the number of perch necessary to displace a measured volume of water to determine total catch. Random samples of fish were measured for length and weight in 1987.

Trawling.-Yellow perch were sampled with a 4 seam semi-balloon otter trawl during September-October of 1986, and July-August of 1987. The trawl was constructed with a 4.3 m head rope, 38.1 mm stretch mesh body, 31.8 mm stretch mesh cod end, and a 6.4 mm mesh cod end liner. The net was towed with a 4.6 m long boat powered by a 50 horsepower outboard engine. The trawl was towed with 2 lines (warps); one attached to each otter board. The warps were fastened to a 3.7 m spreader bar attached midship to allow the net to spread fully.

The trawl was fished on the bottom. Warp lengths were adjusted depending on water depth at each sampling site to avoid lifting the net off the substrate. In 1986, maximum warp length was 46 m long which allowed a minimum warp length of 3 times the depth of water fished. In 1987, warp lines were lengthened to 82.3 m which allowed us to use warp lengths 6 to 10 times the water depth. The net was set and retrieved by hand: one worker handled each warp line. During retrieval the boat was driven at reduced speed to allow retrieval but still prevent fish from escaping out the mouth of the net.

Trawl hauls were conducted at speeds from 0.8 to 1.28 m/s (depending on depth) for 5 to 20 minutes during 1986. We assumed that perch were equally susceptible to capture at speeds from 0.8 to 1.28 m/s and adjusted catches to the equivalent of a 5 minute haul at 1.28 m/s or a linear distance of 384 m. In 1987 all sampling was done at 1.28 m/s for 5 or 10 minutes. All sampling was done during daylight in 1986 and during day and night in 1987.

In 1986, 22 trawl hauls were made at randomly selected locations throughout the reservoir (Figure 3). In 1987, the reservoir was divided into three depth strata; shallow (0-4.6 m), intermediate (4.5-9.1 m), and deep (>9.1 m), to reduce sample variance and to identify strata that might be representative of the entire reservoir. We sampled 66 locations in the three stratum during daylight in 1987; 15 shallow, 47 intermediate, and 4 deep (Figure 3). To determine if night sampling would be more effective than day sampling we trawled at 21 sites once during the day and once at night between 14-30 July, 1987. Sites were trawled both day and night within the same 24 hour period when possible.

Trawl catches were counted and a subsample of yellow perch was randomly selected for assessment of total length, weight, and sex. Scale samples were taken from selected length classes. All catches were standardized to the equivalent of a 5 minute haul at 1.28 m/s.

Gill Netting.-Yellow perch were sampled with experimental gill nets during August 1986. Horizontal gill nets measuring 1.8 m deep x 38.1 m long (stretch meshes 2.54, 5.08, 7.62, 10.16, and 12.70 cm) and 1.8 m deep x 45.7 m long (stretch meshes 2.54, 3.81, 5.08, 6.35, 7.62, 8.89, 10.16, and 12.70 cm) were fished from the surface to the bottom at 1.8 m intervals. The nets were set in a line; the first on the surface, the next set at 1.8 m, and each subsequent net set 1.8 m below the top of the previous net. Midwater sets were suspended by float jugs attached to the float line at 6.4 m intervals. Nets were set to fish continuously from surface to a depth of 7.3 m or 9.1 m depending on location. Nets were set just prior to darkness and retrieved the following morning.

Five gill net stations were selected on the basis of most frequently used sites in past research (Figure 4). Three to 5 nets were fished for 2 nights at each location during the sampling period. Catches were enumerated and total length of all fish was measured.

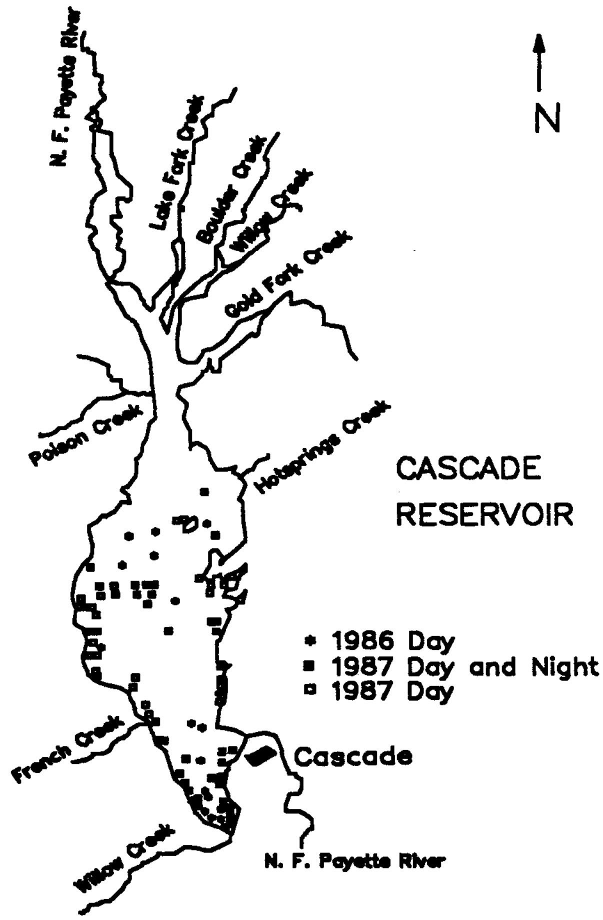

Figure 3. Trawling locations for 1986 day and 1987 day and night sampling in Cascade Reservoir.

Creel survey.-An abbreviated creel survey was conducted during 1987 to determine if a limited amount of angler effort, catch, and catch per unit effort data could be used as an index of age II and older yellow perch abundance. Anglers were contacted on 1 randomly selected weekend day per week beginning 13 June and continuing until 22 August. Contacts were made by 1 or 2 workers at bank angling locations and boat ramps. Each sampling day 1 or 2 workers would drive around the reservoir interviewing as many anglers as possible in an 8 hour day. Total hours fished, number of anglers in each party, boat versus bank fishing, number of fish caught by species, and total lengths and weights of fish in creels were recorded.

Catch per unit effort was determined for age II, III, and IV and older yellow perch. Boat and bank angler catch data was analyzed separately, however, because of similarities in fishing techniques for various species in the reservoir, catch data was not separated by species sought or fishing technique. A standard unit of effort was 1 rod fished for 1 hour.

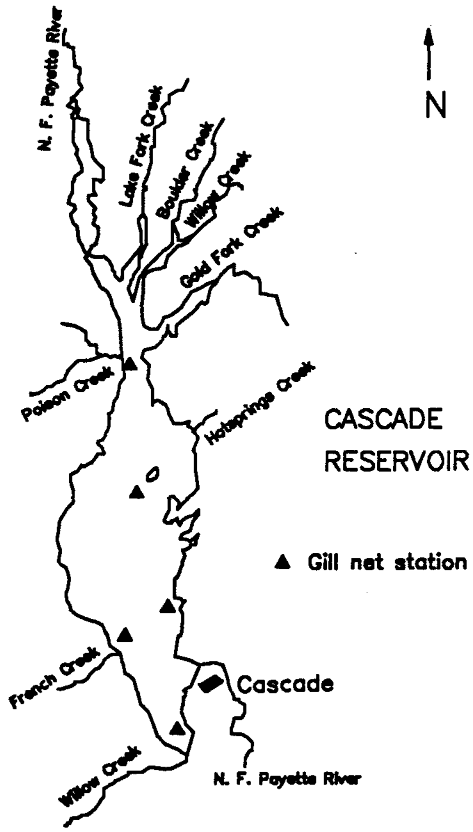

Figure 4. Gill net sampling locations in Cascade Reservoir, 1986.

Age and growth

Yellow perch included in the age and growth analysis were collected during May-October 1986 with seine, trawl, gill nets, and rod and reel; and from June-August 1987 with seine, trawl and creel survey. Sex was determined by dissection. Total (1987) and fork lengths (1986) were measured to the nearest 1.0 mm. Weight was determined with handheld scales. Fish weighing <50, 50-150, and 151-500 g were weighed to the nearest 0.5, 2, and 5 g, respectively.

Age of yellow perch was determined from length frequency histograms and scale analysis. Scales were taken from the left side, one or two rows above the lateral line directly below the insertion of the anterior dorsal fin (Joeris 1957). Scales were cleaned in distilled water and impressions were made on cellulose acetate sheets using a hydraulic press equipped with heating plates. Scale impressions were made using 10,000 lbs pressure at 150°F for 10 seconds. Impressions were projected with a microfische reader with 37.5X magnification. Age was determined by counting annuli. The distance from the focus to each annulus and the anterior margin was measured to the nearest 1.0 mm to determine the body scale relationship.

The relation between scale radius and body length was determined by polynomial regression of total length, anterior scale radius, and anterior scale radius squared:

$$TL = a_1+b_1(ASR)+b_2(ASR)^2 \quad [1]$$

where: TL = Total body length (mm,)
ASR = anterior scale radius x 37.5 (mm),
a_1 = y-intercept,
b_1 = expected change in TL for each unit change in anterior scale radius,
b_2 = expected change in TL for each unit change in (anterior scale radius)^2.

Length at annulus formation was backcalculated with the direct proportion method:

$$L_i = C+(S_i/S)*(L-C) \quad [2]$$

where: L_i = Length of fish when annulus i was formed, L = Length of fish at capture,
S_i = Length of scale radius to annulus i,
S = Length of total scale radius,
C = Correction factor (equivalent to length at scale formation).

Age-length keys were constructed from age and length data collected during August 1986 and 1987. The keys were constructed by splitting August perch catches into 5 mm length classes and determining the proportion of fish in each age class within each length class (Ricker 1975). Catches were then multiplied by these proportions within each length class to estimate age class composition of summer perch catches.

The total length-fork length relationship was calculated for yellow perch in 1986 using geometric mean functional regression (Ricker 1975) :

$$Fl = Tl(b')+a' \quad [3]$$

where: F1 = fork length (mm),
T1 = total length (mm),
b' = slope,
a' = y-intercept.

Total length-weight relationships were calculated with geometric mean functional regressions of log total length and log weight (Ricker 1975):

$$\log w = (\log 1)(b')+a' \quad [4]$$

where: log w = log of weight (grams), log 1 = log of total length (mm), b' = slope,
a' = y intercept.

Fulton's condition factor was calculated to allow comparisons of perch condition between years at Cascade Reservoir and with other perch populations:

$$\text{Fulton's } K = w/l^b \qquad [5]$$

where: b = 3,
w = weight (grams),
1 = total length (mm).

Results

Spawning

Egg strands that had washed up on the shore were observed throughout the main reservoir south of Poison Creek. The highest numbers were recorded in the central portion of the reservoir along the east and west shore while few egg strands were observed in the northern portion of the reservoir (Figure 5). Observations of egg strands deposited on a submerged conifer, located near Sugerloaf Island, indicate yellow perch spawned from approximately 28 April to 11 May in 1986, and surface water temperatures ranged from 8 to 11.5'C during this time period. Spawning activity peaked on 30 April with 5 egg strands deposited during a 24 hour period.

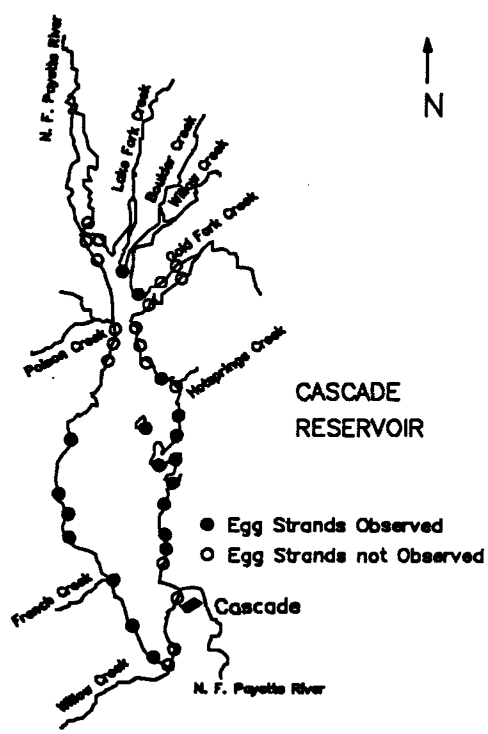

Figure 5. Locations where yellow perch egg strands were observed during May and June, 1986, on the shoreline of Cascade Reservoir.

Indicies of abundance

Tow nets.-In 1986, 791 yellow perch were captured in tow nets compared to 26,111 in 1987. Yellow perch were the only fish species captured in tow nets during both years.

Mean total tow net catches of age 0 perch in 1986 during daylight were highest during the first sampling period (May 28 to June 2) with a mean catch of 10.7 t 3.4 (95% confidence interval) per 5 minute haul. Catch rates declined to 6.7 t 2.0 during the second sampling period (June 11-13) and were lowest during sampling period 3 (June 24-27) at 0.3 ± 0.2 (Figure 6).

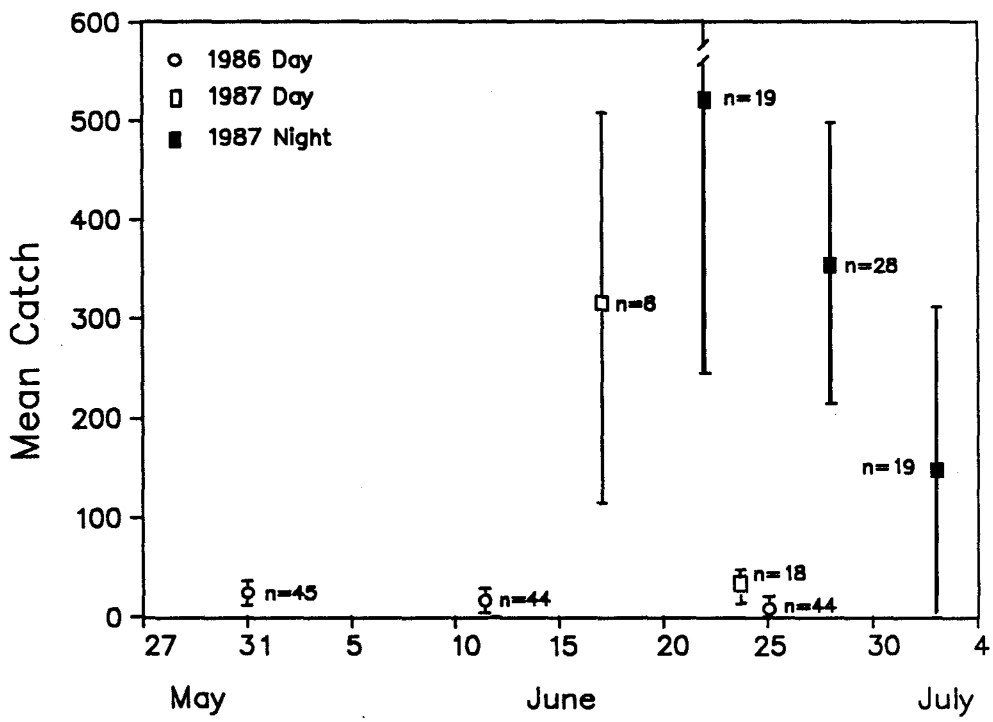

Figure 6. Mean tow net catch with 95% CI of age 0 yellow perch for 1986 day and 1987 day and night sampling in Cascade Reservoir.

In 1987, mean daylight catch rates were 311.0 ± 195.8 from 15-19 June and 38.9 ± 27.7 from 22-25 June, 1987. Catch rates at night werehighest between 19-24 June (mean 521.9 t 286.9) and declined over time to a low of 151.9 ± 159.9 during July 1987 (Figure 6).

Mean total length of age 0 yellow perch caught in tow nets during 1986 and 1987 ranged from 8.9 mm.in May 1986 to 22.5 mm in July 1987, reflecting growth over time (Figure 7).

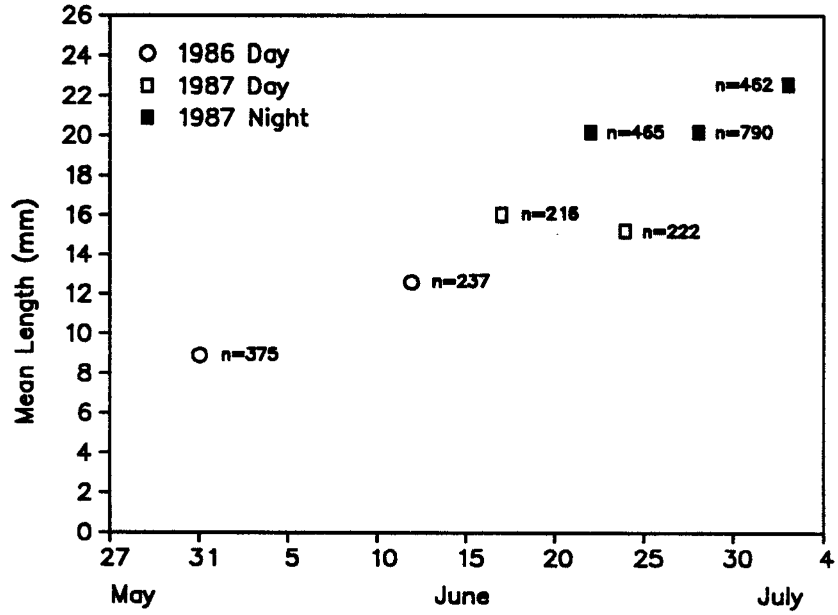

Figure 7. Mean total length of yellow perch captured with tow nets in Cascade Reservoir during May-June 1986 and June-July 1987.

In 1987 the mean catch at night (474.7 ± 228.7 fish/tow) was significantly larger (paired t test, $p = 0.004$) than the mean catch during the day (122.65 ± 78.03) between 15-25 June (Figure 8). Larvae captured during night sampling were larger than fish captured during daylight (Figure 9).

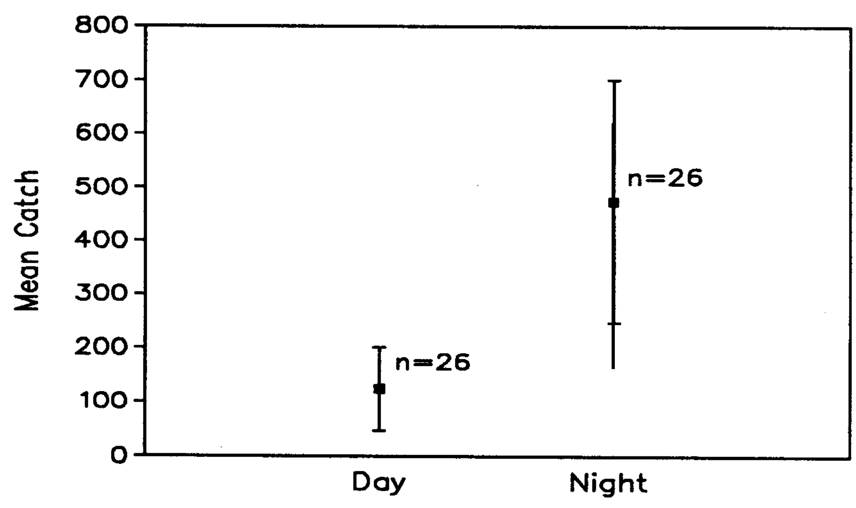

Figure 8. Mean catch per 5 minute tow at 1.28 m/s of yellow perch with 95% CI for day versus night tow net sampling in Cascade Reservoir, 15-25 June, 1987.

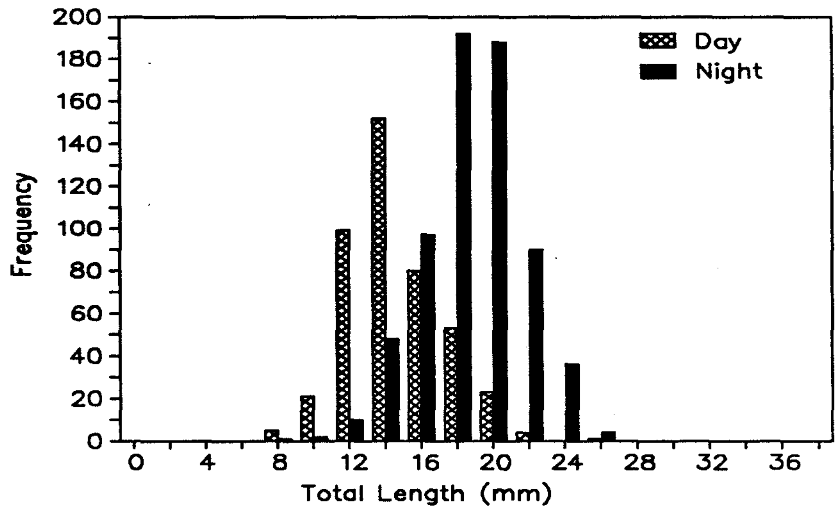

Figure 9. Length frequencies of yellow perch captured during day versus night with tow nets in Cascade Reservoir, 15-25 June 1987.

Seining.-In 1986, 2,103 yellow perch were captured in 39 beach seine hauls during September. The catch was made up of 72.4% age 0 perch (1522 fish), 27.1% age I (569), 0.5% age II (10), and 0.1% age III (2). Mean catch per seine haul was 39.0 ± 19.3 age 0 perch and 14.6 ± 15.3 age I perch (Figure 10). During October, the total catch of yellow perch was 618 in 36 seine hauls. Mean catch declined to 16.3 ± 19.1 age 0 and 0.8 ± 1.0 age I perch (Figure 10).

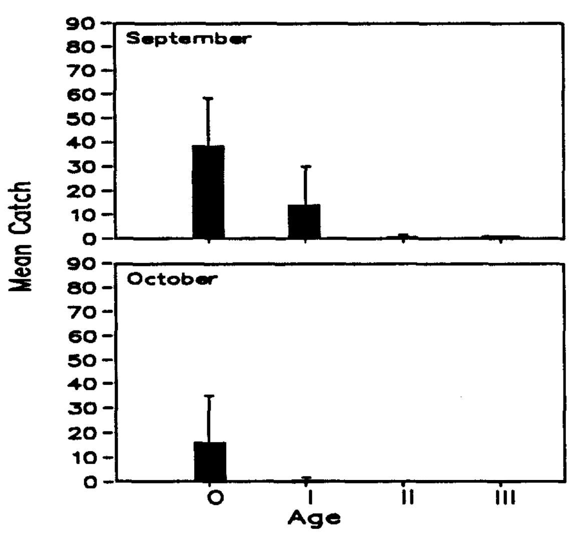

Figure 10. Mean catch with 95% CI of age 0,I, II, and III yellow perch captured in a beach seine in Cascade Reservoir during September (n=39) and October (n=36), 1986.

In August and September 1987, 253,324 perch were captured in 49 beach seine hauls. The catch was 99.9% age 0 perch (252,987 fish), with 20 age I, 26 age II, 288 age III, and 4 age IV and older perch. Mean catch per seine haul was 5163 t 1990 age 0 perch and 0.4 t 0.4 age I perch. Mean catch of age 0 yellow perch per haul was significantly larger in 1987 than in 1986 (Mann-Whitney p 0.0001), but the reverse was true for age I perch (Figure 11).

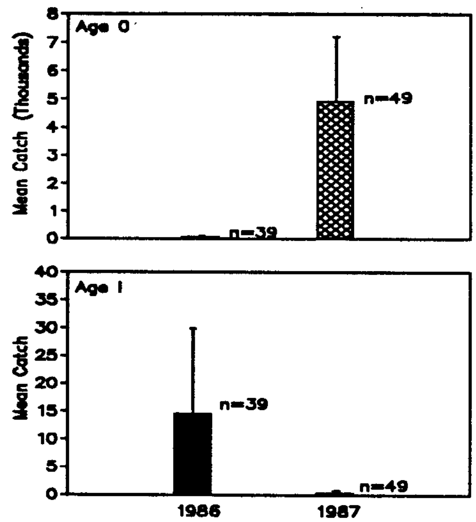

Figure 11. Mean catch with 95% CI of age 0 and age I yellow perch captured in a beach seine in Cascade Reservoir during September 1986 and August-September 1987.

Trawling.-In September and October 1986, 804 perch were caught in 22 daytime trawl hauls. The total perch catch consisted of 24.8% age I (200), 64.5% age II (520), 10.0% age III (80) and 0.3% age IV and older fish (3). Perch catch per standardized haul (5 minutes at 1.28 m/s) was 4.3 ± 4.0 age I, 16.1 ± 13.0 age II, 2.5 t 3.5 age III, and 0.1 t 0.3 age IV and older perch (Figure 12).

In July and August 1987, 3120 perch were caught in 66 daytime trawl hauls. The perch catch consisted of 1.5% age I (46), 7.5% age II (234), 88.2% age III (2752), and 2.8% age IV and older fish (88). Perch catch per 5 minute haul was 0.7 t 0.5 age I, 3.5 t 2.6 age II, 41.8 ± 20.6 age III, and 1.3 ± 0.6 age IV and older fish (Figure 12).

Trawling was conducted between 1.6 and 12.2 m depths in 1986, but perch were only captured at depths between 3.7 and 9.1 m. In 1987, we sampled between 1.8 and 12.1 m depths and caught perch between 1.8 and 10.7 m depths (Figure 13).

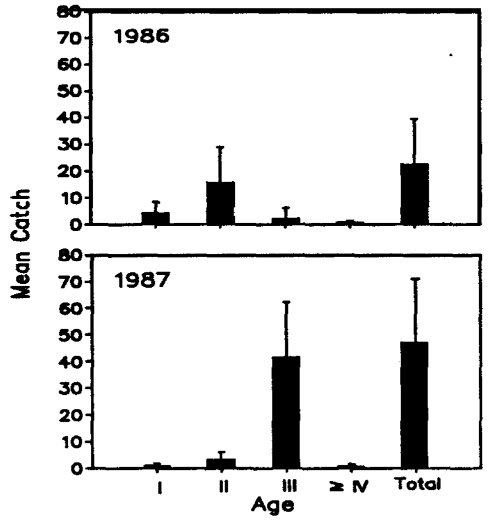

Figure 12. Mean catch with 95% CI of age I, II, III, and IV and older yellow perch captured with a trawl in Cascade Reservoir during September-October 1986 (n=22) and July-August 1987 (n=66) during daytime.

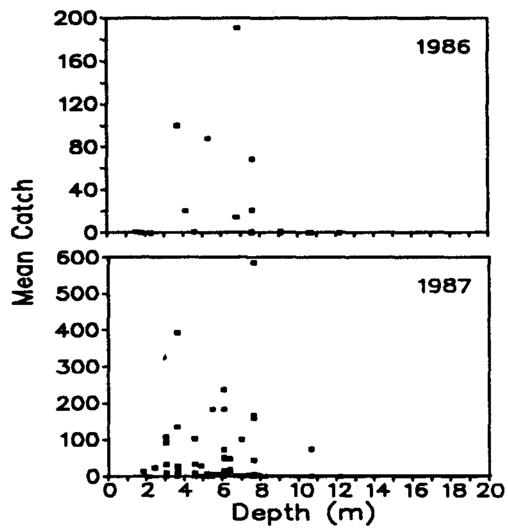

Figure 13. Trawl catch per 5 minute haul at 1.28 m/s of yellow perch by depth in daytime in Cascade Reservoir, 1986 and 1987.

Trawling was conducted at 21 locations during day and night in July 1987. Mean catch of perch was not significantly different (paired t, $p = 0.789$) for day (mean.= 110.2 t 63.8) and night (mean = 121.1 ± 53.0) trawl hauls (Figure 14). Length frequency distributions of perch caught during day and night were similar (Figure 15).

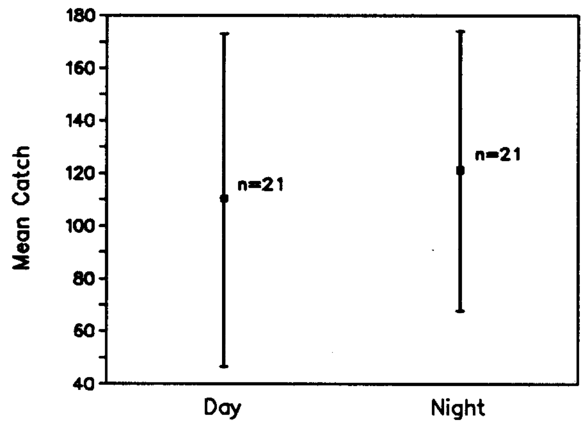

Figure 14. Mean catch per 5 minute haul of yellow perch for day and night trawling in Cascade Reservoir, July 1987.

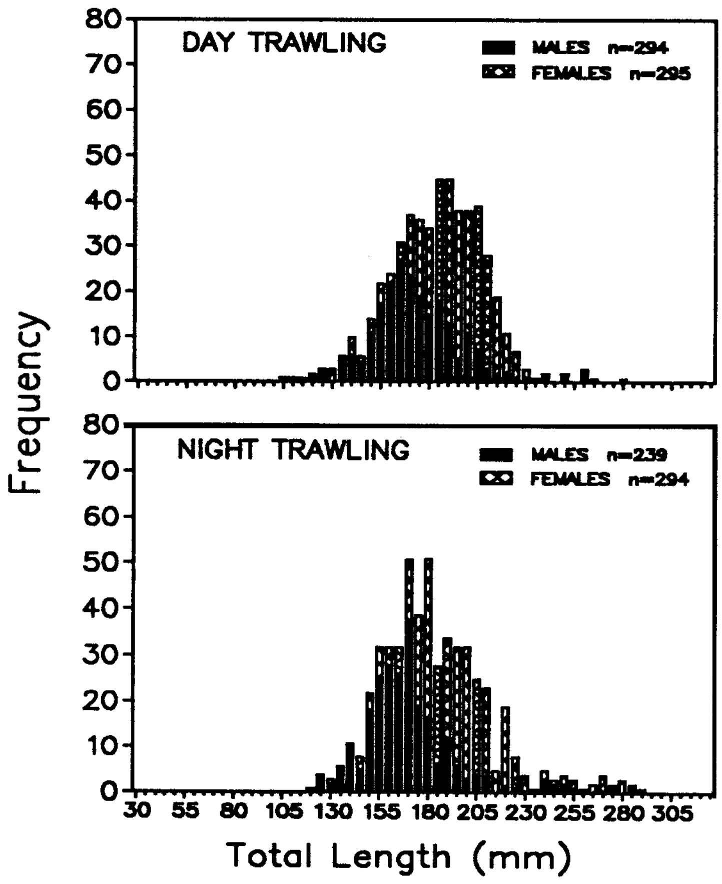

Figure 15. Length-frequency of yellow perch captured in a trawl during day and night sampling at Cascade Reservoir, July 1987.

Gill Netting.-During August 1986, 756 yellow perch were caught in gill nets. The catch consisted of 85 age I (11.2%), 393 age II (52.0%), 130 age III (17.1%), and 149 age IV and older perch (19.6%). Males made up 24.6% of the perch catch and females 75.4%. Yellow perch made up 11.3% of fish caught in surface nets, rainbow trout 9.1%, coho salmon 1.1%, kokanee salmon 3.3%, northern squawfish 56.6%, sucker *(Catostomus spp.)* 14.6%, and bullhead *(Ictalurus spp.)* 4.0% (Figure 16). Species composition for all depths combined (0-9.1 m) was 43.5% yellow perch, 4.0% rainbow trout, 1.5% coho salmon, 2.2% kokanee salmon, 24.2% northern squawfish, 19.6% sucker, 4.0% bullhead, and 1.0% whitefish (Figure 16).

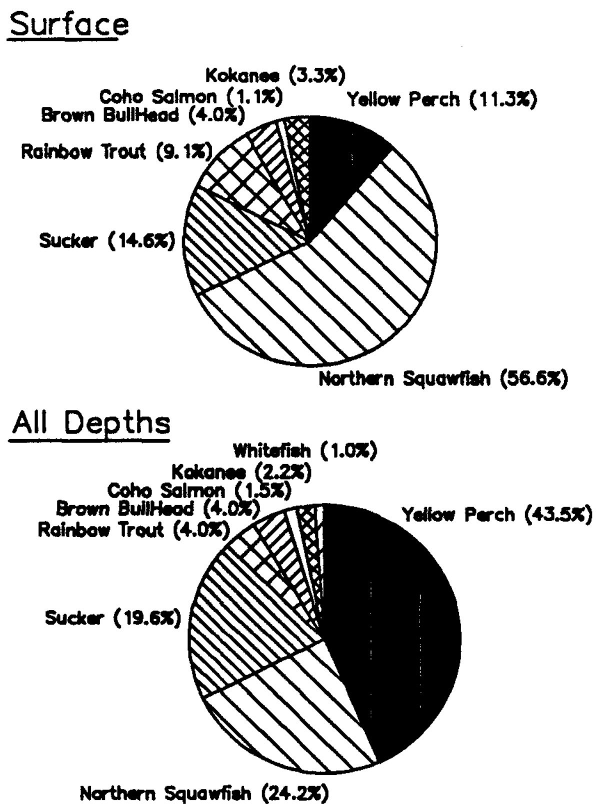

Figure 16. Species composition of experimental gill net catches (surface and all depths) in Cascade Reservoir, August 1986.

In past studies, species composition has been assessed at Cascade Reservoir using gill nets fished at surface and sub-surface primarily. Species composition of gill net surface catches in 1986 was similar to those found in 1969 and 1972 (Figure 17). In 1959 and 1973, northern squawfish were relatively more abundant than in other years, but the sample size was small in 1973 so that comparison may be of limited value.

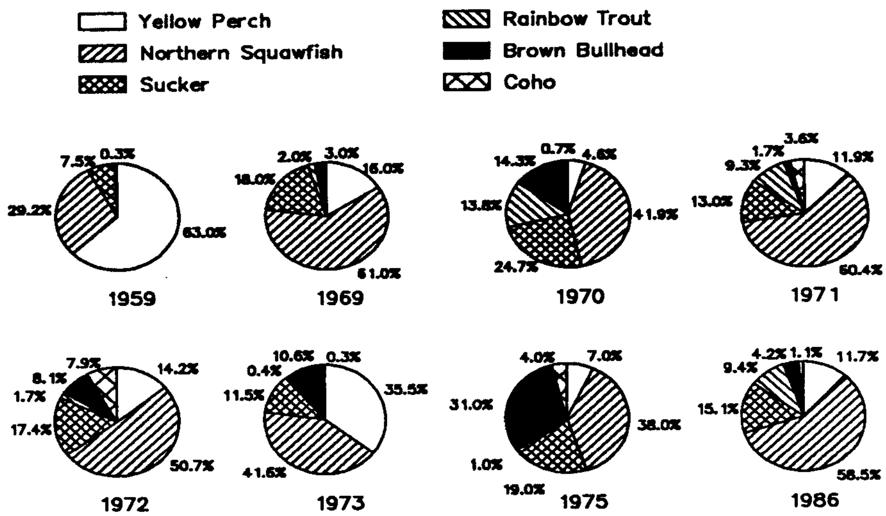

Figure 17. Species composition of surface gill net catches in Cascade Reservoir, 1959-1986.

Species composition from catches at all depths in 1986 was similar to that found in 1980 and 1981 (Figure 18), with gill nets and fyke nets used in the latter two years. In 1968 squawfish were most abundant in Merwin trap catches and least abundant the next year in gill net catches. Yellow perch have been the most abundant species in the 1980's.

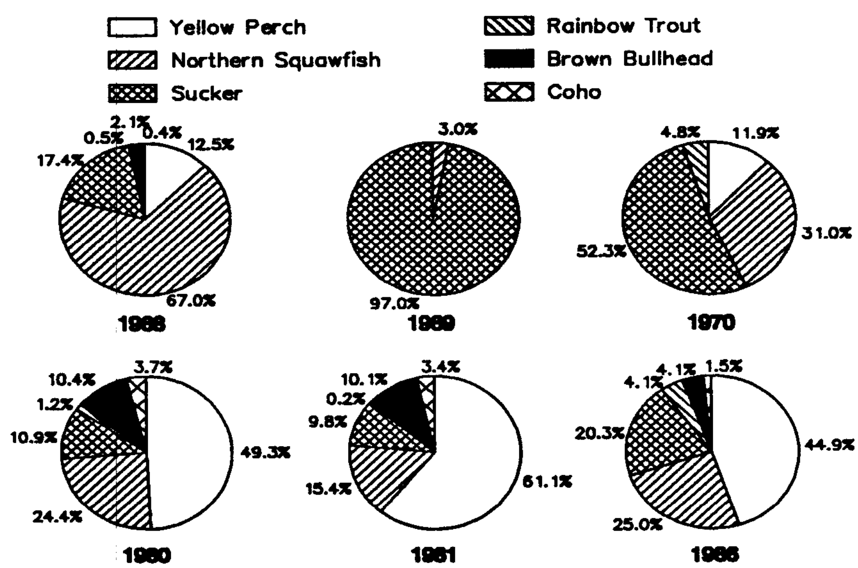

Figure 18. Species composition of vertical gill net catches in Cascade Reservoir, 1968-1986.

Creel Survey.-Between 13 June and 22 August 1987, anglers fishing from the bank were surveyed and they had fished 803 hours and caught 1,617 yellow perch. Anglers fishing from boats fished 1,218 hours and caught 2,096 yellow perch. Catch rates for boat anglers were lowest during June (1.4 perch) and highest during August (2.2 perch) (Figure 19). The age composition of the catch (2% age II, 82% age III, and 16% age IV and older perch) was similar for both boat and bank anglers and did not vary much during the summer of 1987.

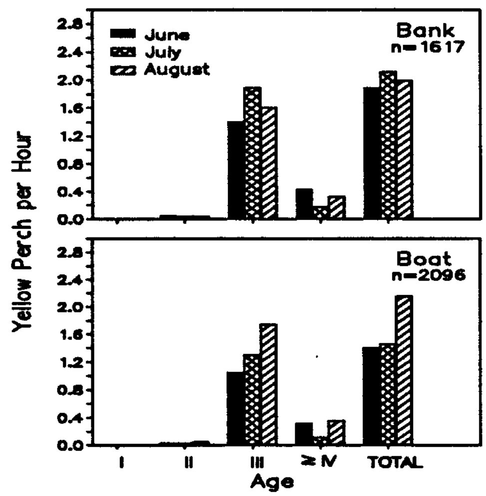

Figure 19. Catch rates of age I, II, III, and IV and older yellow perch by bank and boat anglers at Cascade Reservoir during June, July, and August, 1987. Sample size refers to number of perch caught by anglers in survey that were measured.

Catch rates of yellow perch by boat anglers in 1987 were similar to those found in 1975, 1980, and 1986 and higher than all the other years previously studied (Figure 20). Bank anglers had higher catch rates of yellow perch in 1987 than in any year previously investigated. Catch rates of boat anglers are probably more indicative of consumptive fishing success on the reservoir, because bank anglers tended to catch and release more smaller fish, which were included in catch rates. Released fish were not measured by creel clerks, therefore the size and age composition reported is for fish that were kept.

Age and growth

Length frequency distributions and scale analysis were used to age yellow perch captured with rod and reel, beach seine, trawl, and gill nets. Scale measurements of 336 yellow perch captured in 1986 and 1987 were used to determine the body-scale relation of yellow perch in Cascade Reservoir. The relation between anterior scale radius (ASR) and body length (TL) was curvilinear (Figure 21).

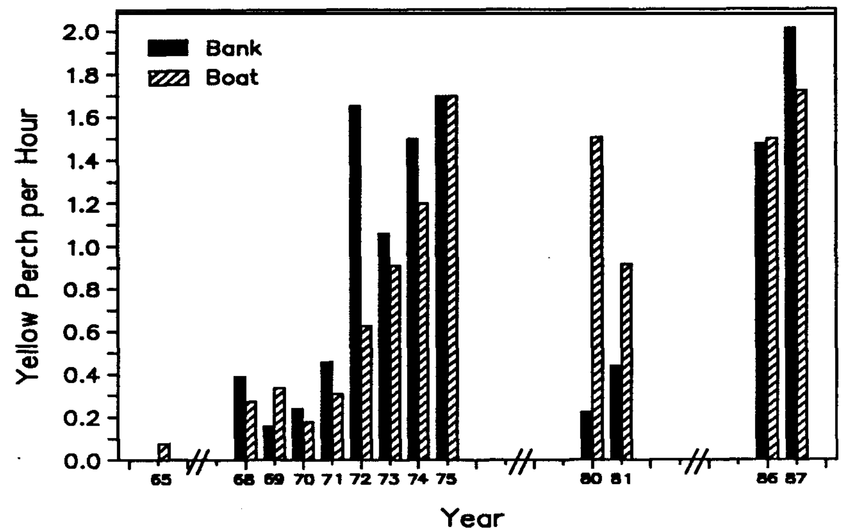

Figure 20. Catch rates of yellow perch by bank and boat anglers at Cascade Reservoir, June-August 1965-1987.

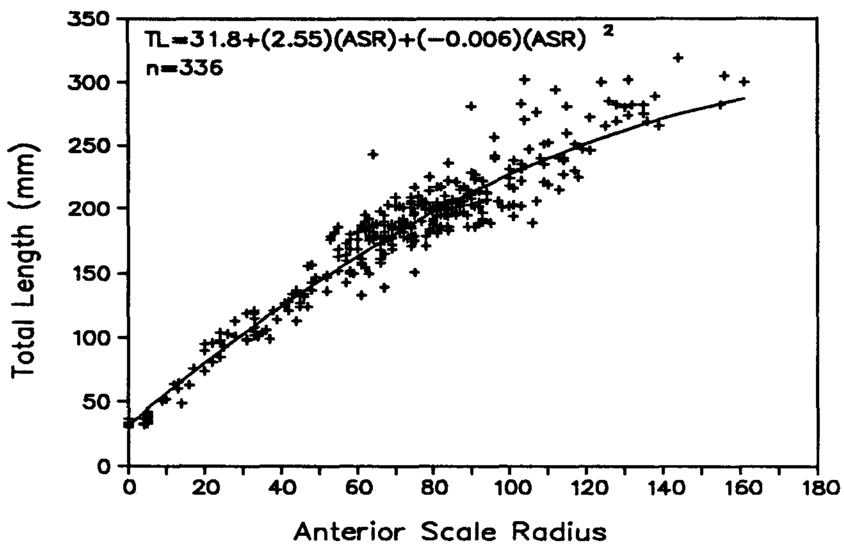

Figure 21. Relation between anterior scale radius (mm * 37.5) and total length of yellow perch in Cascade Reservoir, 1986-1987.

Length at annulus formation was backcalculated for 188 female, 92 male, and 7 unsexed perch with the proportional method. The oldest perch sampled were age VIII females. Females were longer than males by age II (Table 1).

Cascade Reservoir supported a relatively fast growing perch population. At age 3, yellow perch in Cascade Reservoir were longer than all but one of the other populations compared (Table 2).

In 1986, 130 perch were aged to develop an age-length key for use in determining age of perch from length frequency distributions. The length frequency distributions of August catches graphically depict the age-length keys for 1986 and 1987 (Figures 22 and 23). The August age-length keys were used to separate summer catches by age class during both years.

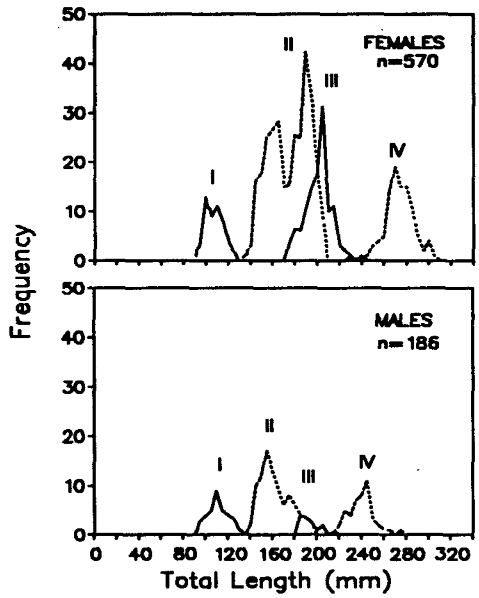

Figure 22. Length frequency distributions for female and male yellow perch age I, II, III, and IV and older, August 1986.

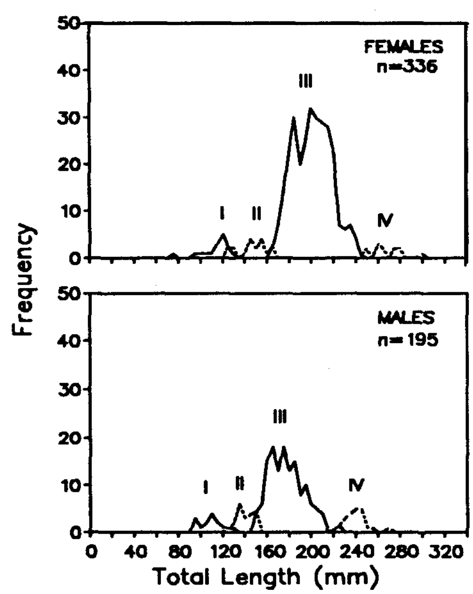

Figure 23. Length frequency distributions for female and male yellow perch age I, II, III, and IV and older, August 1987.

Yellow perch total length-fork length relation (Figure 24) was calculated using geometric mean functional regression for 1295 perch caught in 1986. Total length-weight relations of perch were determined using geometric mean functional regressions of log total length and log weight. Length and weight measurements of 1293 perch were regressed in 1986 (Figure 25) and 250 perch in 1987 (Figure 26) and the relations were described by similar equations:

$$\text{Log } W = \text{Log } TL\ (3.2634) + (-5.5320) \tag{6}$$

$$\text{Log } W = \text{Log } TL\ (3.1413) + (-5.2583) \tag{7}$$

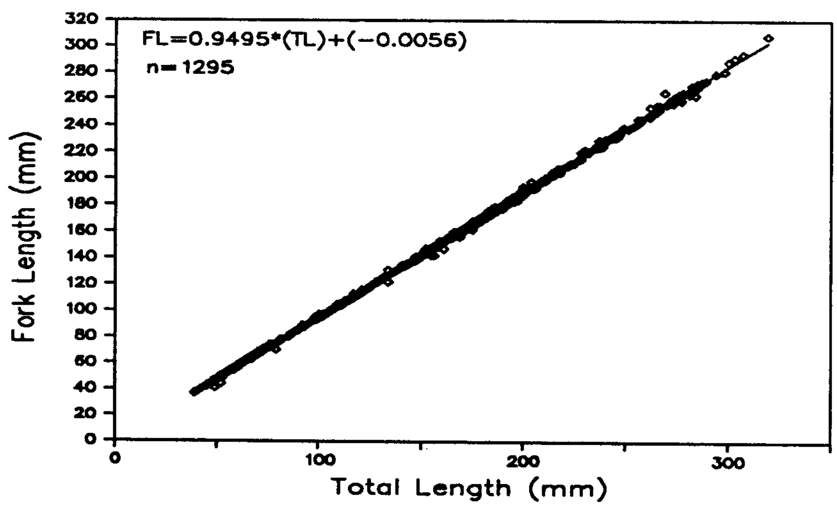

Figure 24. Relation between total length and fork length of yellow perch captured in Cascade Reservoir, 1986.

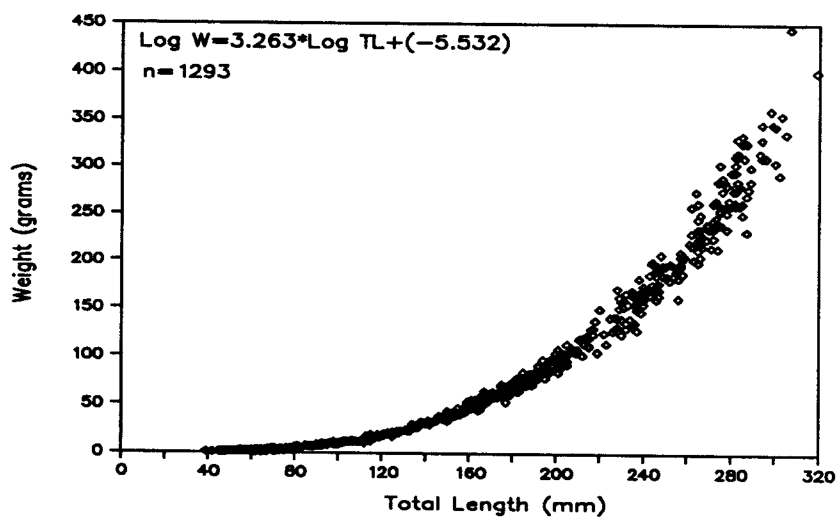

Figure 25. Relation between total length and weight of yellow perch captured in Cascade Reservoir, June-October, 1986.

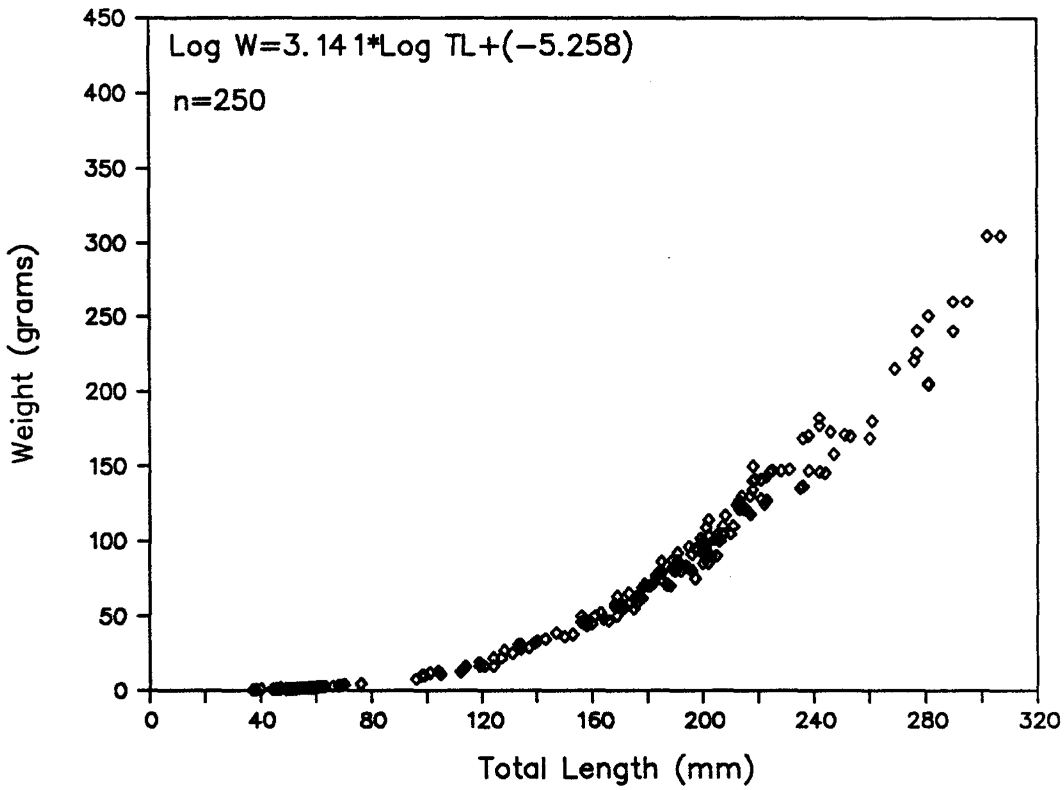

Figure 26. Relation between total length and weight of yellow perch captured in Cascade Reservoir, June-September, 1987.

Length-weight relations of various length classes of yellow perch were compared using geometric mean regressions of perch 37-79 mm (age 0), 90-129 mm (age I), and 180-220 mm (age II and III) (Figure 27). The slope of regression lines (b values) ranged from 2.754 for age 0 perch sampled in 1986 to 3.550 for age I perch sampled in 1987.

Comparisons of body form were made using Fulton's condition factor. This condition factor is not theoretically correct, since b values from length-weight regressions were not equal to 3, but it will provide a basis for comparisons of perch condition between years at Cascade Reservoir and with other perch populations. Condition of all length classes combined was 1.092×10^{-5} in 1986 and 1.104×10^{-5} in 1987 (Table 3). Perch 39-79 mm total length had the lowest condition (0.881×10^{-5} and 0.979×10^{-5} for 1986 and 1987, respectively). Perch 180-220 mm total lngth had the highest condition factors (1.196×10^{-5} and 1.205 x 10°' for 1986 and 1987, respectively).

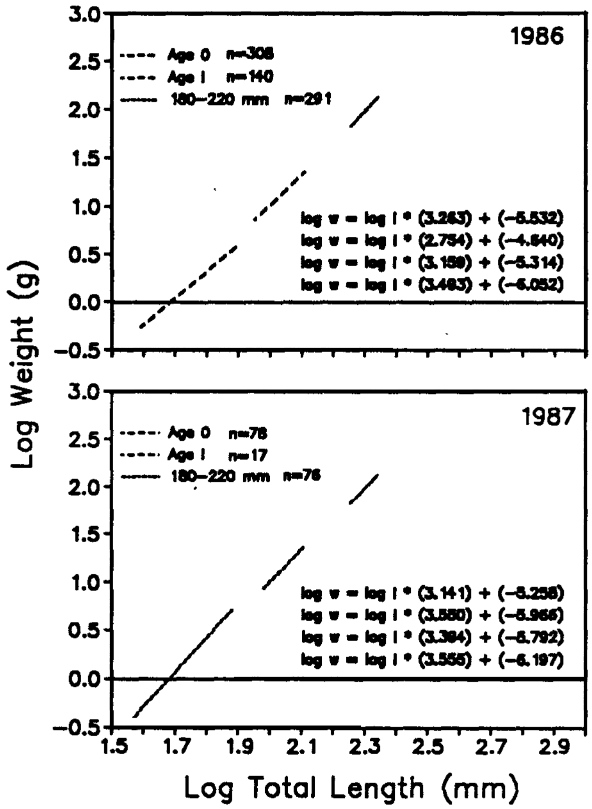

Figure 27. Geometric mean functional regression of log length and log weight for yellow perch 37-79 mm (age 0), 90-129 mm (age I), and 180-220 mm (age II or III) captured in Cascade Reservoir during 1986-1987.

Table 1. Backcalculated length of yellow perch at each age for female, male, and combined sex in Cascade Reservoir in 1986 and 1987.

			Length at Age							
Age	Sex	Number	I	II	III	IV	V	VI	VII	VIII
I	Female	13	71							
	Male	11	70							
	Combined	31	70							
II	Female	81	73	139						
	Male	29	73	128						
	Combined	110	73	136						
III	Female	73	66	122	184					
	Male	37	68	121	165					
	Combined	110	67	122	178					
IV	Female	2	57	105	141	195				
	Male	5	73	125	174	208				
	Combined	7	69	119	165	204				
V	Female	6	65	127	187	220	246			
	Male	8	70	132	176	203	226			
	Combined	14	68	130	180	211	234			
VI	Female	9	63	134	194	225	251	268		
	Male	1	66	122	173	191	208	219		
	Combined	10	63	133	192	222	247	263		
VII	Female	1	66	132	195	225	240	254	269	
	Male	1	66	118	164	177	196	211	229	
	Combined	2	66	125	179	201	218	232	249	
VIII	Female	3	66	125	180	204	224	243	256	272
	Male	0	-	-	-	-	-	-	-	-
	Combined	-	-	-	-	-	-	-	-	-
Total	Female	188	69	130	184	218	245	261	259	272
	Male	92	70	125	168	202	221	215	229	
	Combined	287	70	129	178	211	237	255	251	272

Table 2. Comparison of backcalculated length ar various ages of Cascade Reservoir yellow perch with other yellow perch populations.

		Total length (mm) at annulus											
Location	Sex	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	Source
Cascade Reservoir, Idaho	Male	69	130	184	218	245	261	259	272				
	Female	70	125	168	202	221	215	229	-				
	Combined	70	129	178	211	237	255	251	272				
Lake Erie	Male	91	168	213	239	257							
	Female	94	170	218	249	272	287						
	Combined	94	170	216	241	264	279						Jobes, 1952
Lake of the Woods, Minnesota	Combined	97	137	178	204	230	251	262	278	280	273	303	Carlander, 1950
Lake Oahe, South Dakota	Male	-	128	158	179	201	213						
	Female	-	134	167	191	207	224						Nelson and
	Combined	69	132	165	189	206	219						Walburg, 1977
Lake Sharpe, South Dakota	Male	-	146	155	179	193							
	Female	-	152	170	187	204							Nelson and
	Combined	62	149	167	184	200							Walburg, 1977
Lower Thompson Lake, Montana	Combined	48	86	112	142	168	279						Echo, 1954
Lake Opinicon, Ontario, Canada	Combined	65	96	119	136	151	167	186	280				Keast, 1977

Table 3.- Fulton's condition factor (K) for yellow perch 37-70 mm (age 0), 90-129 mm (age I), 180-220 mm and all length classes combined from Cascade Reservoir 1986-1987.

Length class (mm)	1986 K (x 10)	n	1987 K (x 10)	n
39-79	0.881	308	0.979	78
90-129	1.025	140	1.042	17
180-220	1.196	297	1.205	76
39-319	1.092	1293	1.104	250

Discussion

Yellow perch populations often have large fluctuations in year class strength (Forney 1971; Busch et al 1975; Eshenroder 1977; and Nelson and Walburg 1977), with up to 40-fold changes in abundance for North American perch populations (Forney 1976; Eshenroder 1977; and Nelson and Walburg 1977) and as high as 400-fold for Eurasian perch (Kipling 1976).

At Cascade Reservoir during 1986 and 1987 we found evidence of large differences in abundance of the age groups between years (Table 4). We found evidence that strong year classes of yellow perch were produced in 1984 and 1987, and weak year classes were produced in 1985 and 1986. Evidence for a strong 1987 year class was the catch per unit effort of age 0 perch in tow nets and beach seines; 35 times more fish caught in 1987 than in 1986 in tow nets and 132 times more fish caught in 1987 than in 1986 with a beach seine.

The catch rate of age I fish in a beach seine in 1986 was 36.5 times larger than in 1987, an indication that the 1985 brood year was stronger than the one in 1986. Age I fish were also more abundant in the 1986 trawl catches than in those of 1987.

The 1984 brood year was also relatively abundant based on trawl catch rates of age II fish in 1986 and age III fish in 1987. Fish from the 1984 brood year made up 64.5% (16.1 fish/haul) of the catch in 1986 (age II) and 88.2% (41.8 fish/haul) in 1987. Data from gill netting in 1986 and the creel survey in 1987 support the idea that 1984 was a strong year class, with 52.0% of the net catch and 82.3% of the harvest being from the 1984 brood year.

Factors which may regulate year class strength of yellow perch are numerous, but many studies report a strong meteorological influence (Koonce et al. 1977). Strong year classes of percids generally occur during years with higher and more stable air and water temperatures (Clady 1976; Craig and Kipling 1983; Kallemeyn 1987), while wind velocity is usually negatively correlated with year class strength (Clady 1976; Nelson and Walburg 1977). At the Proceedings of the International Percid Symposium (PERCIS) held in Ontario, Canada in 1976, 23 researchers reported meteorological conditions affecting the abundance of yellow perch year classes (Koonce et al. 1977). Another indication of a strong meteorological influence on year class strength of percids are the synchronous fluctuations in abundance which occur over relatively wide geographic areas (Eshenroder 1977).

Studies which found a relationship between wind velocity and year class strength generally attribute losses to the displacement of egg strands caused by wave action. Wave action can result in significant mortality especially in water bodies lacking suitable substrate for the attachment of egg strands. This condition is common in reservoirs because of low water

Table 4.-Catch rates of yellow perch by age class for tow nets, beach seine, trawl, gill net, and creel survey during 1986 and 1987 at Cascade Reservoir, Idaho.

		Yellow Perch Catch by Age Class					
Age		0	I	II	III	IV	Total
Tow Net - Catch/5 min tow							
1986		3.49	0.00	0.00	0.00	0.00	3.49
1987		122.65	0.00	0.00	0.00	0.00	122.65
Beach Seine - Catch/haul							
1986		39.03	14.59	0.26	0.05	0.00	53.93
1987		5163.00	0.41	0.53	5.88	0.08	5169.90
Trawl - Catch/5 min haul							
1986			4.30	16.05	2.50	0.08	22.93
1987			0.69	3.54	41.70	1.34	47.27
Gill Net - Catch/h/100 m^2							
1986		0.00	0.24	1.10	0.36	0.42	2.12
Creel Survey - Catch/angler h							
1987	Bank	0.00	0.00	0.05	1.67	0.30	2.02
	Boat	0.00	0.00	0.04	1.41	0.27	1.72

levels during the spring spawning period. Clady (1976) reported that physical destruction and displacement of egg strands occurred in Oneida Lake, New York during periods of high winds. Treasurer (1983), however, found no relationship between wind and year class strength of Eurasian perch *(Perca fluviatilis)* in Lochs Davan and Kincord, Scotland where egg strands were deposited over aquatic vegetation. Beckman and Elrod (1971) associated a decline of yellow perch in Lake Oahe in North and South Dakota to a loss of suitable spawning habitat. During filling of the reservoir, and shortly after full storage was reached, they found that inundated brush was utilized for egg deposition and strong year classes of yellow perch were produced. Fish spawned over mud and rubble after the submerged terrestrial vegetation decomposed, and strong year classes were produced only during high water years.

In Cascade Reservoir, yellow perch abundance may be regulated by meteorological conditions during the spawning, incubation, and larval stages. Yellow perch prefer to spawn in shallow water (1-3 m), over submerged vegetation, fallen logs, and other underwater structures. Eggs are extruded in a single gelatinous mass that is semi-buoyant (Scott and

Crossman 1973). In 1986, perch spawned during April and May in Cascade Reservoir over mud and silt substrate. A more suitable substrate for the attachment of egg strands was not present because of low water levels and the absence of innundated terrestrial and aquatic vegetation. Many egg strands were washed onto the shore by frequent spring storms.

At Cascade Reservoir limited sampling each year, using one or more of the techniques investigated in this study, could be used to investigate the effects of wind, water temperature, and reservoir elevation on year class strength of yellow perch. Water temperature data is collected at the dam by Idaho Power Company personnel and reservoir elevation information is available from the Bureau of Reclamation. Wind velocity data is not available at this time. It would be advisable to obtain a portable weather station to measure wind velocity during the spring spawning period. A local homeowner or member of the Concerned Citizens for Cascade Reservoir group (CC4CR) could be recruited to operate the equipment. Correlations of catch, meteorological, and hydrological data could be used to determine if these factors affect yellow perch abundance in Cascade Reservoir.

The techniques which were developed during 1986 and 1987 can be effectively used to follow fluctuations in the abundance of perch in Cascade Reservoir. Depending on the type of information desired and the amount of time and effort available, some techniques will be more beneficial than others. A minimal effort would be the determination of year class strength of age 0 and I yellow perch with beach seine hauls, which could be correlated with meteorological data. Approximately 10 days of effort each year by 2 workers would be needed.

Beach seining was the most effective gear for following fluctuations in perch year class strength. Age 0 and age I perch are vulnerable to capture in a beach seine and have distinct length frequency distributions so age analysis is not necessary. Sampling should be done after 15 August when perch are fully recruited to the seine and completed before 15 September because young perch move offshore during late summer and early fall (Forney 1971). In 1986, our seine catches declined during October, probably a result of an offshore movement.

Clady (1976) and Koonce et al. (1977) reported year class strength of yellow perch was determined by the end of the first summer of life (age 0), but Forney (1971) found year class strength was not established until the second summer (age I). Beach seining data will allow comparisons of year class strength between age 0 and I to determine when year class strength is established in Cascade Reservoir.

Sampling with a seine is relatively easy and inexpensive: two workers with a small boat and a beach seine can average approximately 10 hauls per day and collect length and weight data. The number of seine hauls needed varies, and depends on the abundance of yellow perch. In future years sampling should be initiated and after 10-12 hauls, estimates of sample size should be calculated from the of variance estimate for that year.

Tow netting was effective for determining the relative abundance of larval yellow perch. Results in 1986 and 1987 were consistent with beach seining data, which indicated a strong year class in 1987. However, identifying year class strength using tow nets may be unreliable if year class strength is not fully established early in the first summer of the perch's life. Tow netting is also labor intensive, because larvae must be separated from plankton and debris and identified using a dissecting scope. Tow net sampling would be useful for identifying factors that regulate year class strength, such as the relationship between larval perch abundance and abundance of adult spawners and/or embryos. Tow netting would also provide information on early survival and growth.

If tow net sampling is conducted at Cascade Reservoir, day versus night sampling should be investigated further. We caught more fish at night, however, the comparison was made between 15-25 June, a time when mean length of larva was longer than 15 mm. Larger perch may visually detect and swim well enough to avoid the net (Noble 1970). Perch hatch at 5-7 mm total length and are weak swimmers (Ney 1978). If sampling is conducted soon after hatching, sampling during the day may be as effective as at night. The earliest we sampled larval perch was 28 May 1986 and the perch averaged 8.9 mm in length.

Developing an index of abundance for age II and older perch appears possible using trawling, gill netting, or creel survey, however, it will require a relatively large effort every year. Length frequency distributions of age classes II and older overlap so that an age analysis is necessary each year to determine the number of fish in each age class.

Trawling was useful for sampling age I and older perch, however, some age I fish were caught in the wings of the trawl (38.1 mm stretched mesh) and undoubtedly some smaller fish escaped from the trawl before encountering the liner in the cod end of the trawl. If trawling is used on Cascade Reservoir in future years a reduction in mesh size of the wings and body of the trawl should be considered. Small mesh trawls have been used to sample age 0 perch at the end of the first summer of life (Noble 1975).

Trawling was effective in the southern portion of Cascade Reservoir. Catches were small in the main reservoir north of Crown Point, perhaps a result of the relatively clear water which would enable fish to see and avoid the net. The southern portion of the reservoir was relatively turbid resulting from stagnation and high densities of plankton. North of Sugerloaf Island sampling with the trawl was difficult because of numerous tree stumps and other obstructions. Trawling the southern portion of the reservoir may accurately represent perch abundance in the entire reservoir. Trawl sampling should be conducted at depths between 3-8 m. Two workers can average 9 trawl hauls per day, and collect length and weight data and scale samples. Trawling would be useful for collection of fish for determining the relationship between growth and abundance, obtaining stomach samples for food habit studies, sampling adult perch during the spawning period and determining year class strength.

Gill netting yielded results similar to trawling in 1986 (Table 4), and can be used to determine relative year class strength of age I and older perch, although it was the least preferred method. Gill netting was discontinued after the 1986 field season because it required more effort than other sampling methods. We fished gill nets for 10 days and netted

756 perch compared to 806 perch captured in 5 days of trawling in 1986, and 3120 perch with 10 days of trawling effort during 1987.

The limited creel survey we conducted in 1987 yielded results similar to those found by trawling. Like trawling and gill netting, creel survey data is difficult to separate into age classes with only length frequency data. In 1987, we spent 10 days on the survey and recorded 3713 perch caught by boat and bank anglers.

Scale analysis and age-length keys were necessary to determine age of fish during the summer and calculation of length at various ages was used to determine length at annulus formation. Length frequency data was useful for determining mean lengths of age 0 and I perch, but not older perch. A complete scale analysis is necessary each year that indices of abundance are developed for perch older than age I.

Perch populations may exhibit compensatory changes in growth in response to changes in population density. At low densities growth may increase while the opposite occurs at high levels of abundance (Schneider 1975; Nelson and Walburg 1977). Not all attempts to correlate growth with levels of abundance have been successful (Forney 1971; Ney and Smith 1975; Noble 1975). Noble (1975) stated that high densities of young perch could reduce numbers of *Daphnia* through predation resulting in reduced growth of young perch, but he found little relation between levels of perch abundance and growth. He believed that numerous other factors were involved in regulating *Daphnia* production in Oneida Lake. Other researchers have found growth correlated with temperature (Jobes 1952; Ney and Smith 1975), food availability (Ney 1978; Mills and Forney 1983) and length of growing season (Nakashima and Leggett 1975). Variable growth rates of perch are a result of meteorological and biological processes which affect food availability and utilization, competition, and predation (Ney and Smith 1975).

Growth of yellow perch in Cascade Reservoir was variable during 1986 and 1987. Based on the age-length keys developed for fish collected in August, female and male perch age II and III were longer in 1986 than the same age fish in 1987 (Figures 22 and 23). Identification of factors which affected growth rates were beyond the scope of this study and more direct comparisons of growth between years was not possible with our data because of differences in size selectivity of sampling gear.

Male and female perch in Cascade Reservoir grow similarly until age II when females were longer and heavier than males. These findings are similar to those of Brazo et al. (1975); other studies have detected differences in growth between males and females beginning at age I (Scott and Crossman 1973).

Perch were heavier for a given length in 1986 ($b = 3.26$) than in 1987 ($b = 3.14$) based on length-weight regressions (Figure 25 and 26). Perch in Cascade Reservoir weighed less at a given length than perch in Lake Michigan ($b = 3.30$-3.40) (Brazo et al. 1975). Condition of age 0 perch was higher in 1987 ($b = 3.55$), a strong year class, than in 1986 ($b = 2.75$) when young perch were less abundant. Condition of perch 90-129 mm and 180-220 mm was also higher in 1987 than in 1986 (Table 3).

Fulton's condition factor assumes an unchanging body form (b = 3) but the actual values calculated from length-weight regressions of our data ranged from 2.75-3.56. Condition of perch was higher in 1987 when strong year classes of age 0 and IV fish were present, than in 1986 when age III perch were most abundant.

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